Adaptive Spectral Reconnaissance Program (ASRP)

Defense Science & Technology Seminar
Emerging Hyperspectral Technologies -
New Eyes for the Warfighter

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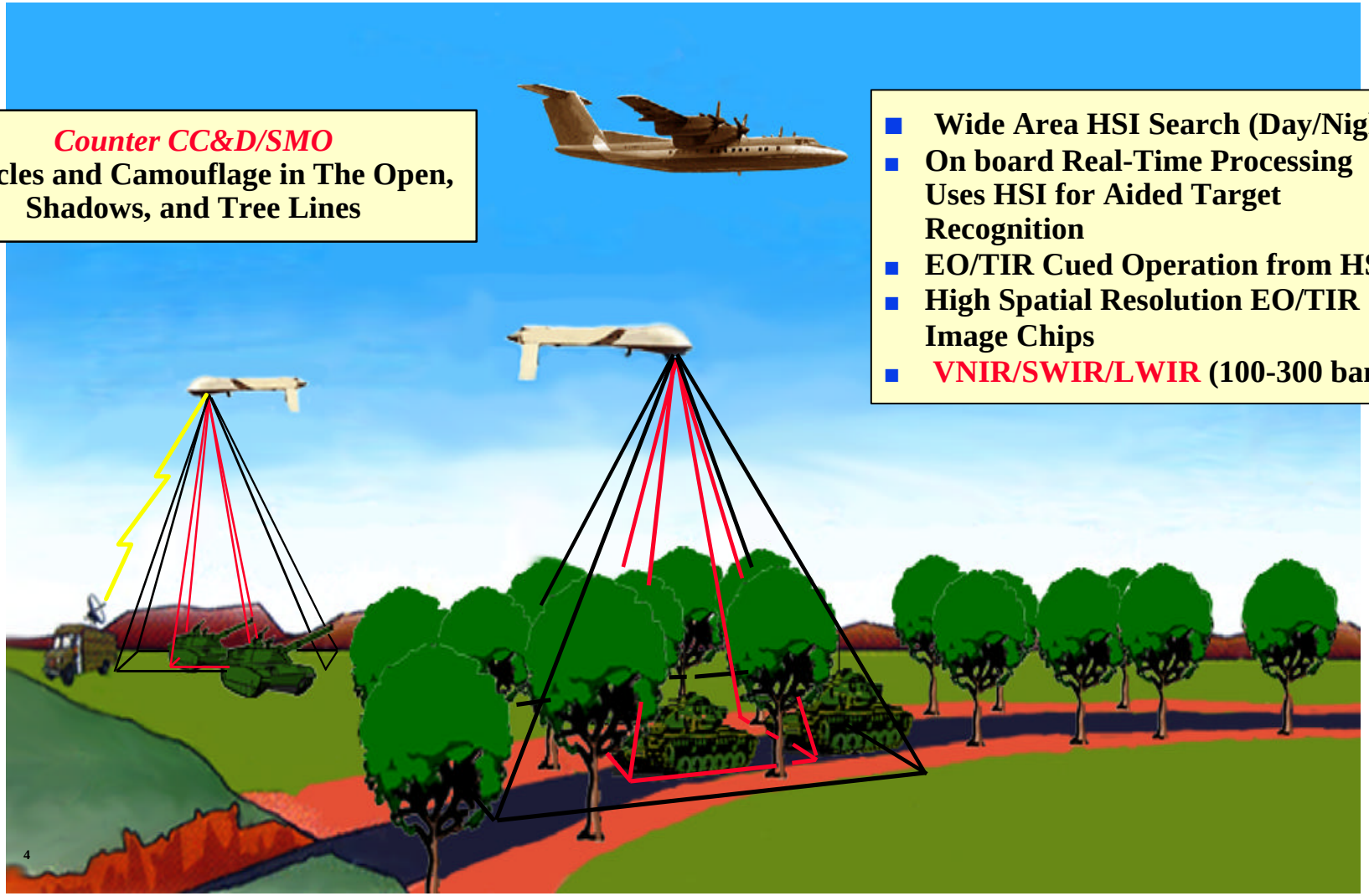
ASRP Tactical Vision

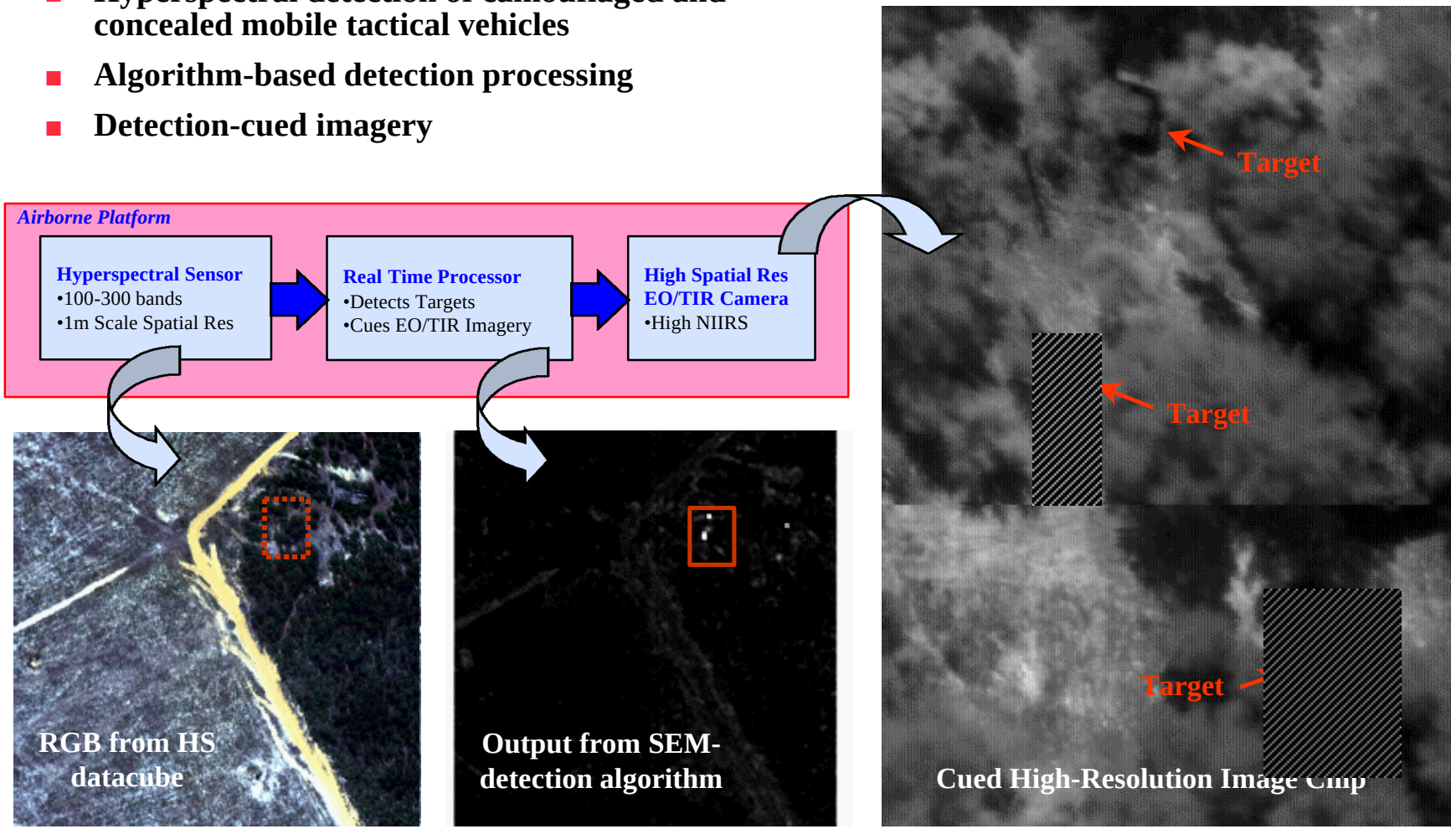
Counter CC&D/SMO
Vehicles and Camouflage in The Open, Shadows, and Tree Lines



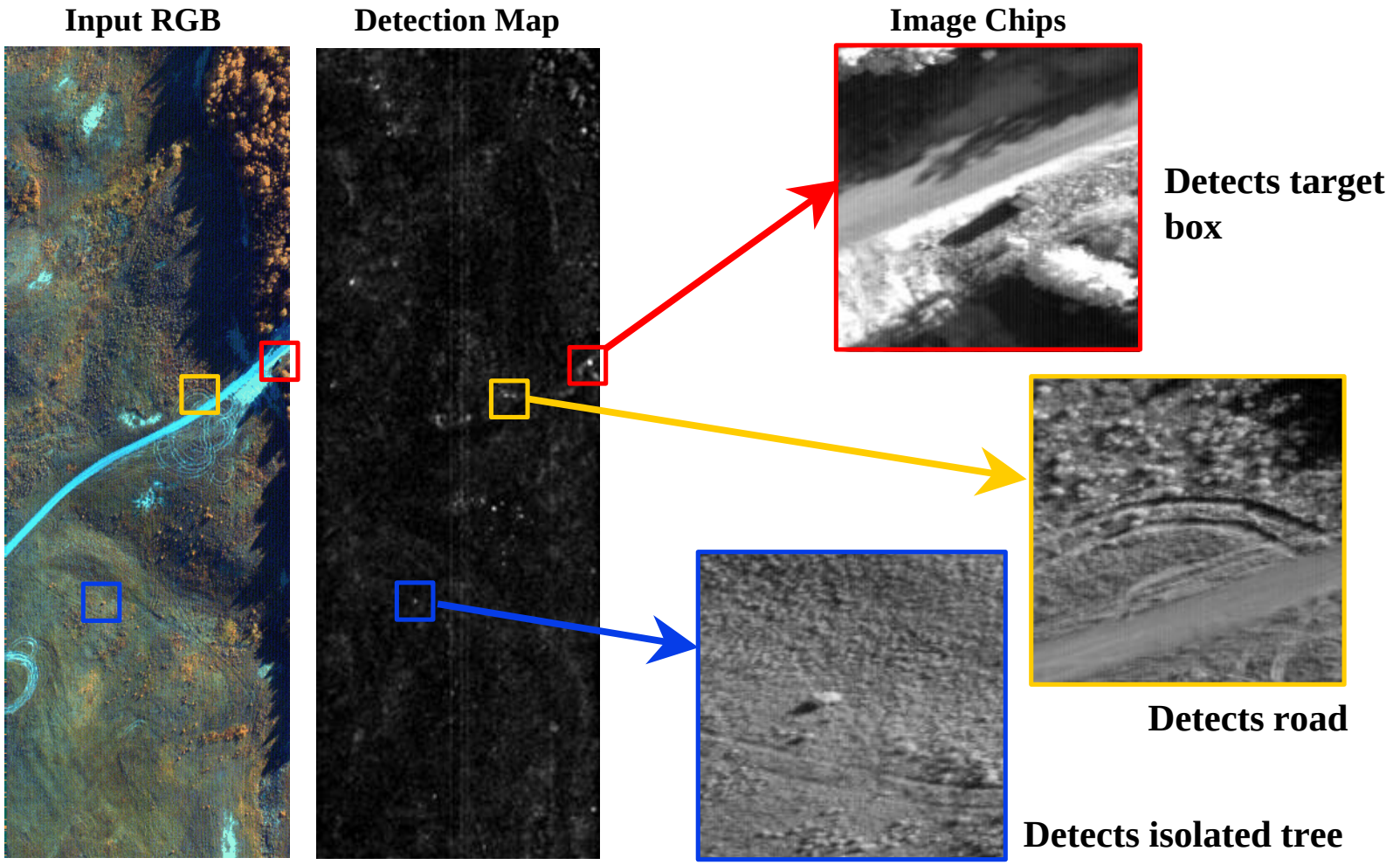
- **Wide Area HSI Search (Day/Night)**
- **On board Real-Time Processing Uses HSI for Aided Target Recognition**
- **EO/TIR Cued Operation from HSI**
- **High Spatial Resolution EO/TIR Image Chips**
- **VNIR/SWIR/LWIR (100-300 bands)**

ASRP Target Detection and Cueing Concept

- Hyperspectral detection of camouflaged and concealed mobile tactical vehicles
- Algorithm-based detection processing
- Detection-cued imagery



Target Detection Challenge (Aided Target Recognition)



Standard metric: P_D vs. FAR **Goal:** High P_D and Low FAR **Benefit:** Less Warfighter Load

Adaptive Spectral Reconnaissance Program (ASRP)
FY97-FY00

- **Goal: Build the technical underpinnings for future MSI/HSI systems to counter camouflaged, and concealed surface targets**

- **Approach: Focus attention on 4 key technology thrusts**
  - Analytic models and algorithms
  - Data analysis/ signature database
  - LWIR sensor development
  - Data collections / demonstrations

- **Plan: Transition HS technology to airborne platforms (TUAV, ARL/ACS, HAE UAV and MAE UAV)**

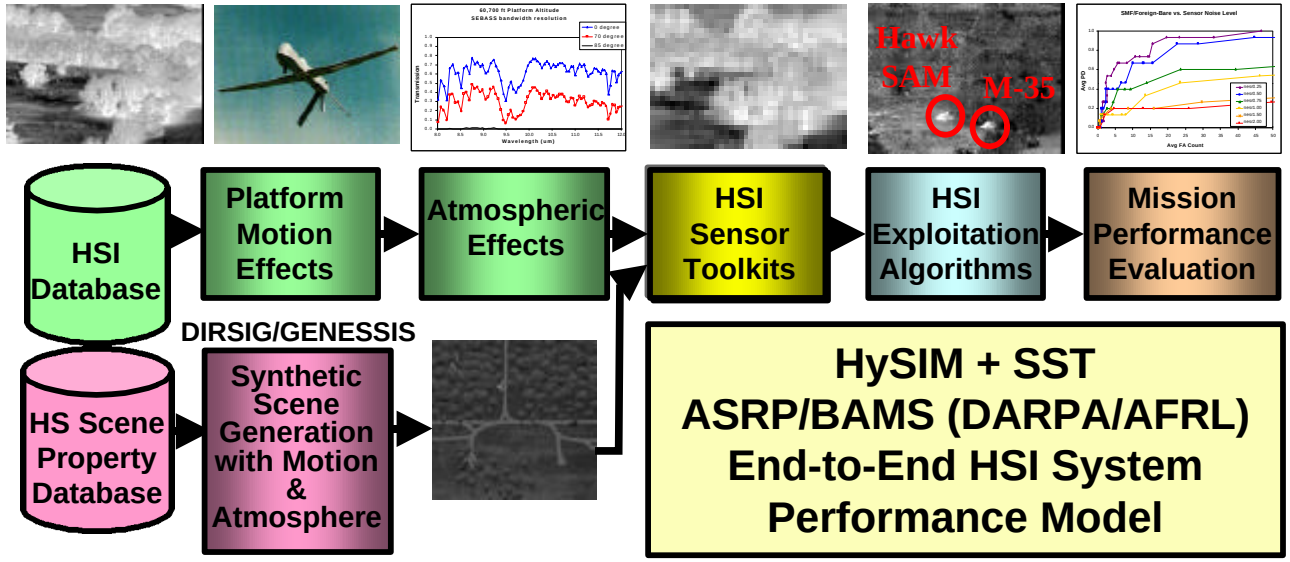
- **Legacy:**
  - Performance prediction tools
  - Robust-low FAR target detection algorithms
  - "Book" on VNIR/SWIR target detection
  - Phenomenology database

Technology Challenges

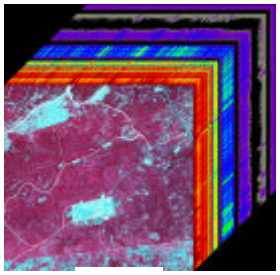
- **Models and tools for performance prediction/trades**
- **Algorithms (high P_D/low FAR) ➔ Reduces analyst load**
- **Compact LWIR HSI and TIR imager sensors**
  - Spectral/spatial resolution, low NESR (SWAP)
- **High-throughput real-time airborne processors**

Modeling

■Hyperspectral System Image Model (HySIM)



■Scene generation optimized for wide area surveillance and localized regions



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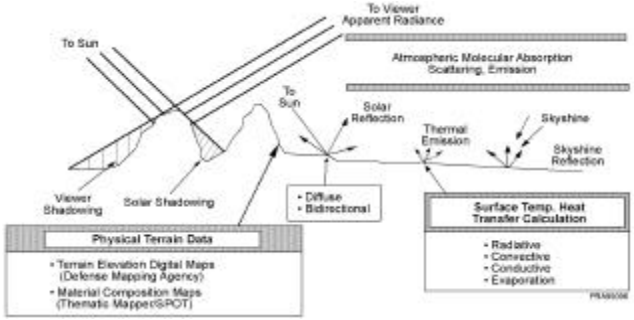
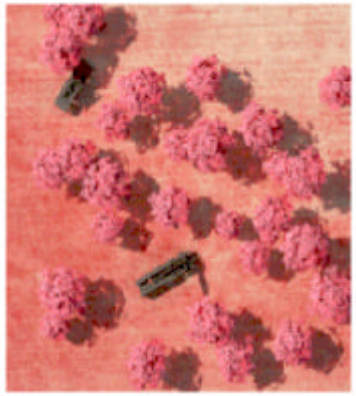
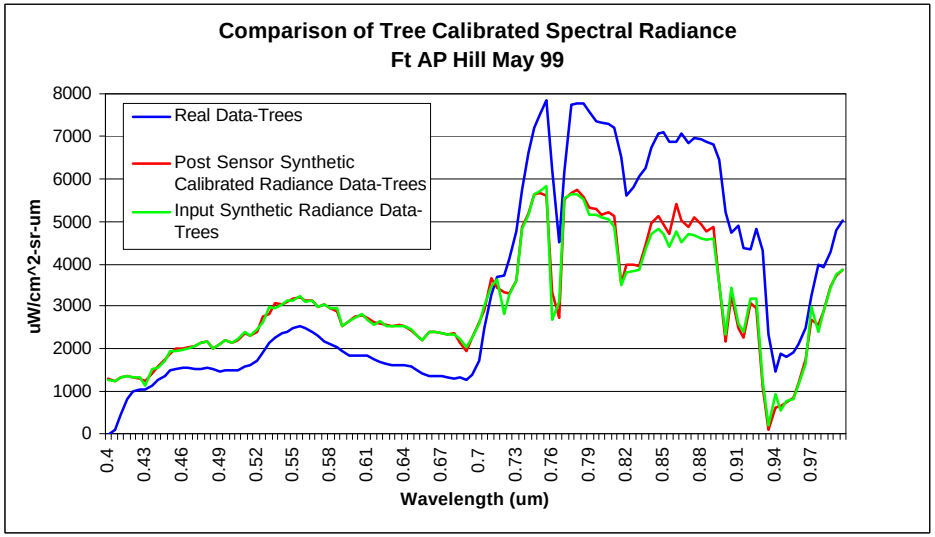
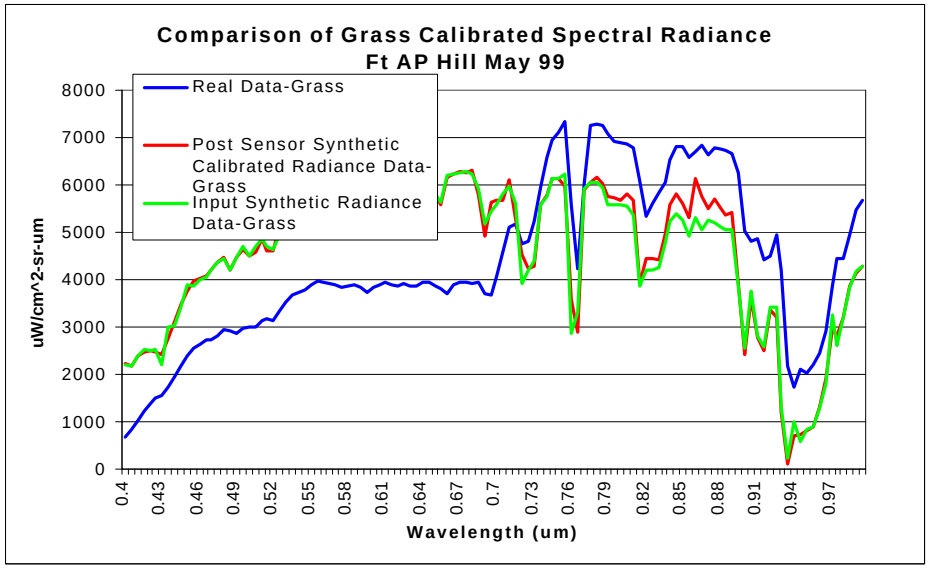




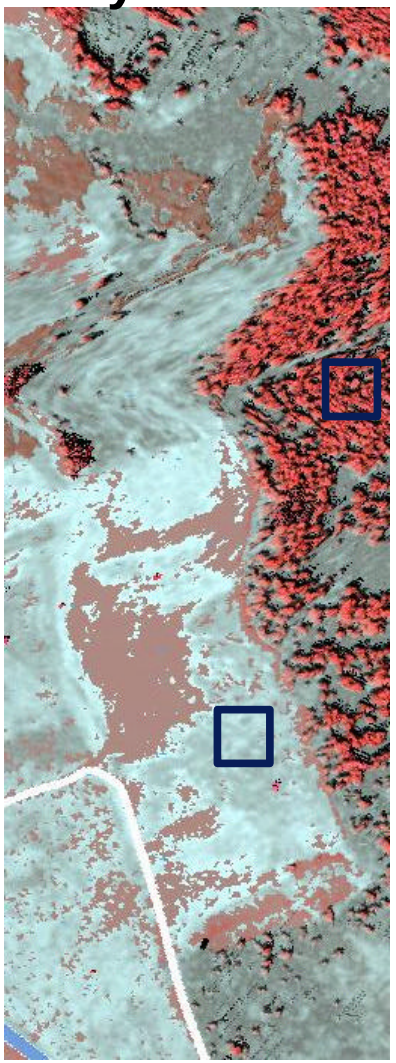
Preliminary Modeling Results (NVIS/VNIR)

Actual





Synthetic



Algorithm Development

Challenge: **Target detection algorithms must overcome the high variability of targets and backgrounds in a scene; multiple algorithms and fusion offer a potential solution**

Approach: ***Evaluate current SOA, include new algorithms (Red Team recommend)****

Implement multiple algorithms (>3) using fusion and in real time

Include advanced preprocessing, core detection, and postprocessing

Evaluating

- **Anomaly Detection**
  - **R-X (local/stochastic)**
- **Clustering**
  - **SEM (global/stochastic)**
- **Linear Unmixing**
  - **ORASIS (global/deterministic)**
- **Recognition /Atmos. Correction**
  - **PALM/VANTAGE (reflective)***
  - **ISAC (emissive)***

Analysis & Assembly

Analysis & Fusion

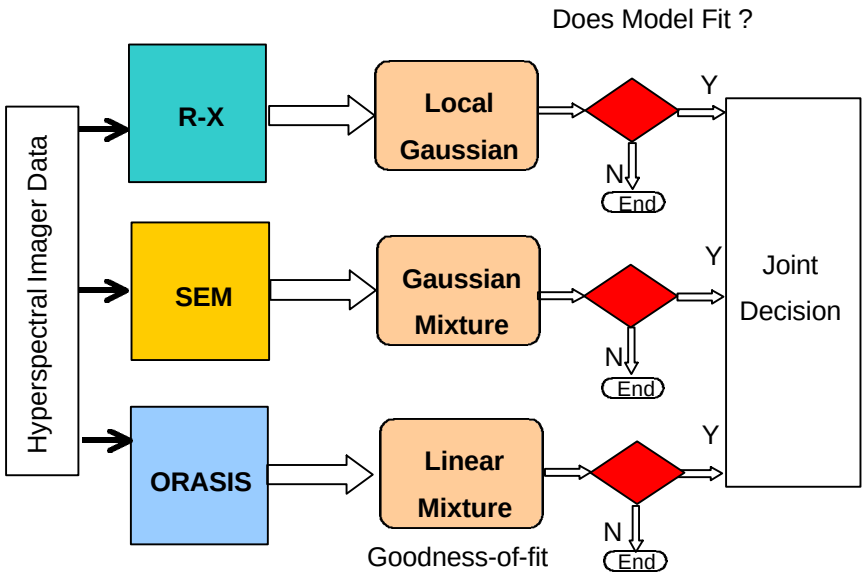
(High P_D/Low FAR)

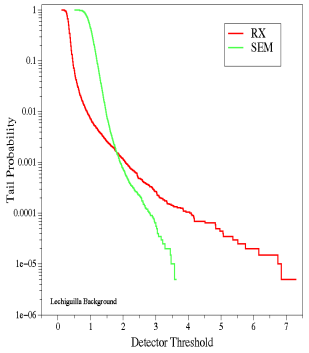
Verification

- **Data collection and analysis**
  - **flights**
  - **ground truth**
  - **image truth**
  - **model comparison**
  - **validation**
- **Significant target and background data**
  - **9 collects ~1.5TBytes**

Fusion

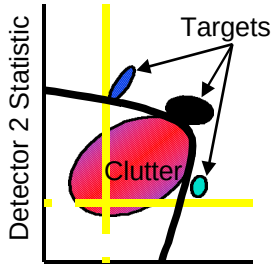
- **Algorithm Segmentation/Selection**



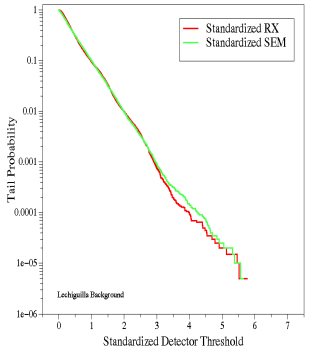


RX,SEM Detector Tails
(Lechiguilla Background)

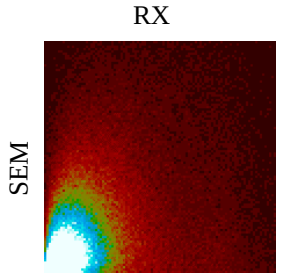
- Model-Based "Standardization" of Anomaly Detector Distributions



Detector 1 Statistic

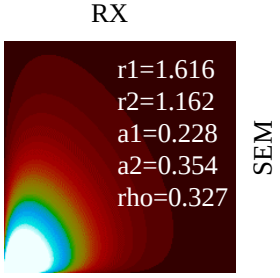


Standardized RX,SEM
Tails Based on
Dual-Gamma Model



2-D Detector Histogram
(Standardized RX & SEM)

- Bivariate gamma model can be "fit" to standardized detector outputs



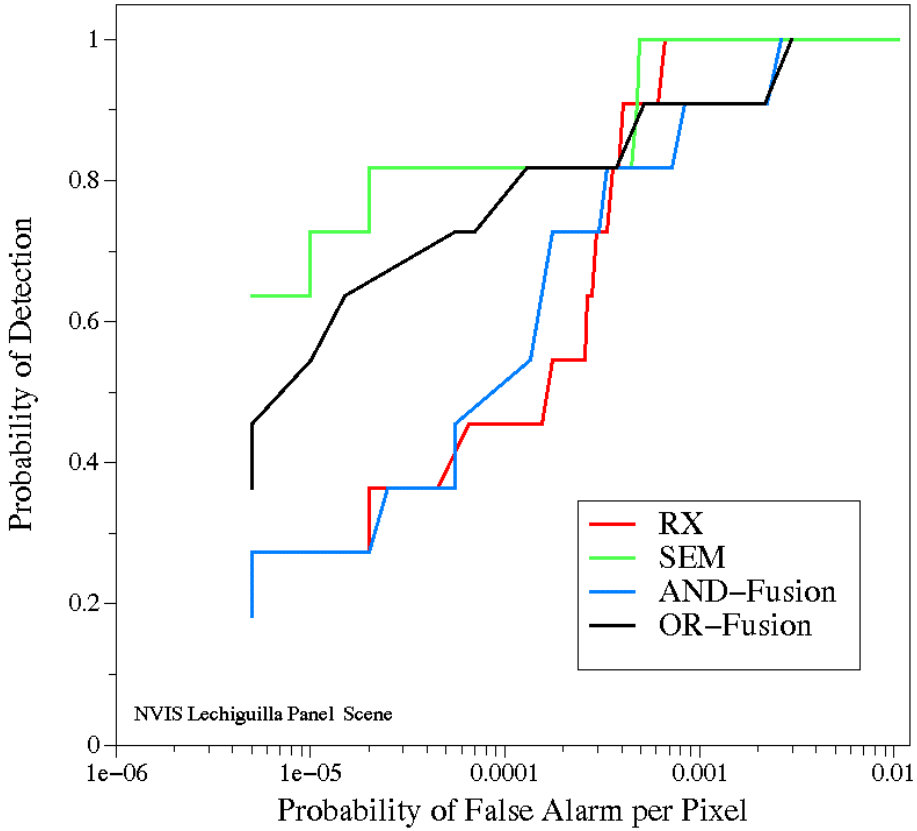
Joint PDF Fit w/ Parameters
Estimated by Least-Squares

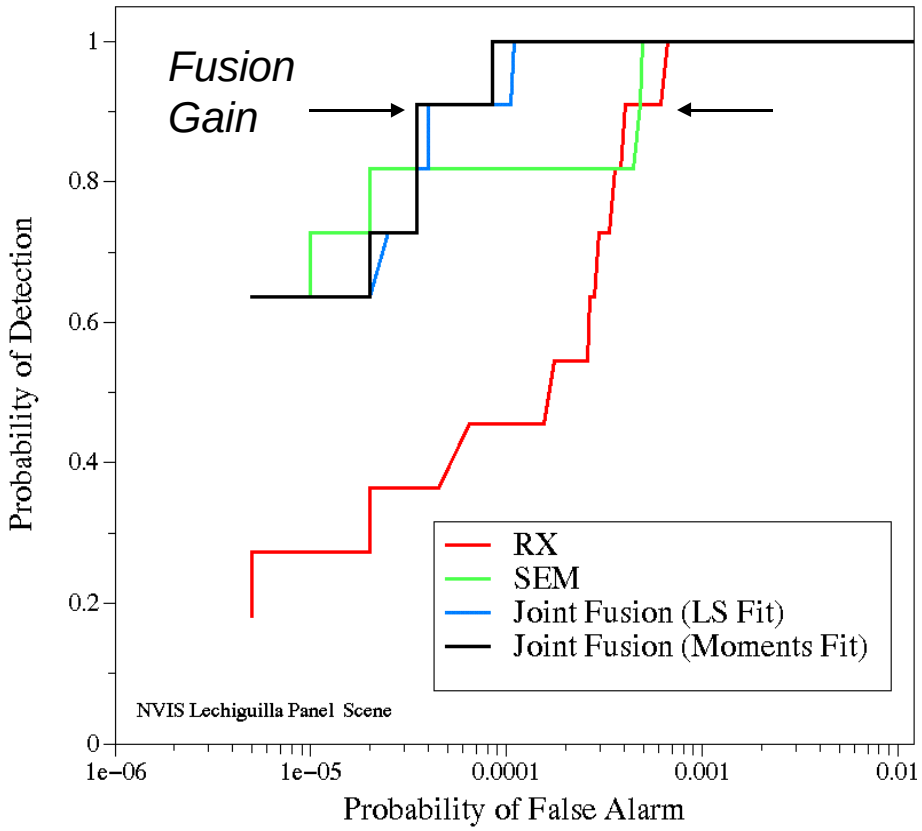
- **Algorithms are fused with joint decision statistic**
- **Goodness-of-fit over local/regional areas determines applicability of each particular algorithm**

Fusion Results
NVIS Lechiguilla Scene

- AND/OR fusions of RX and SEM (at equal-Pfa thresholds) perform worse than the best single detector (SEM)

- Joint fusion threshold tests outperform RX and SEM in the high-Pd regime





HSI Military Payoff

- **Addresses the critical gap in the detection of camouflaged vehicles in the open and targets concealed in treelines and in shadows --- Kosovo shortcoming**
- **Improvement in tactical productivity and situation awareness through "aided" target detection and recognition capabilities**
- **Enhancement of P_k and shortened time-lines in difficult target detection scenarios by cueing PGMs and other weapons platforms**